Aran, Galway Bay and Slyne Head *Nephrops* Grounds (FU17) 2018 UWTV Survey Report and catch scenarios for 2019.

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Abstract

This report provides the main results and findings of the seventeenth annual underwater television on the Aran, Galway Bay and Slyne head *Nephrops* grounds, ICES assessment area; Functional Unit 17. The survey was multi-disciplinary in nature collecting UWTV, fishing, CTD and other ecosystem data. In 2018 a total of 43 UWTV stations were successfully completed, 33 on the Aran Grounds, 5 on Galway Bay and 5 on Slyne Head patches. The mean burrow density observed in 2018, adjusted for edge effect, was medium at 0.40 burrows/m². The final krigged burrow abundance estimate for the Aran Grounds was 488 million burrows with a CV (relative standard error) of 3%. The final abundance estimate for Galway Bay and Slyne Head was 33 million in both grounds with CVs of 17% and 12% respectively. The total abundance estimates have fluctuated considerably over the time series. The 2018 combined abundance estimate was a 37% increase compared to in 2017 and at 554 million burrows and is above the MSY $B_{trigger}$ reference point (540 million burrows). Using the 2018 abundance estimate and updated stock data implies catch of 1002 tonnes and landings of 916 tonnes in 2019 when the MSY approach is applied (assuming that discard rates and fishery selection patterns do not change from the average of 2015–2017). *Virgularia mirabilis* was the only sea-pen species observed on the UWTV footage. Trawl marks were present at 9% of the Aran stations surveyed.

Key words: *Nephrops norvegicus,* stock assessment, geostatistics, underwater television (UWTV), benthos, CTD.

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Introduction

Nephrops norvegicus are common around the Irish coast occurring in geographically distinct sandy/muddy areas where the sediment is suitable for them to construct their burrows. The *Nephrops* fishery in ICES sub-area 7 is extremely valuable with landings in 2017 worth around €54 million at first sale. The *Nephrops* fishery 'at the back of the Aran Islands' can be considered the mainstay of the Ros a Mhíl fleet. Estimated landings of 295 t in 2017 were worth approximately €2.1 m at first sale. Without this *Nephrops* fishery the majority of vessels in the fleet would cease being economically viable (Meredith, 1999). Given these socio-economic realities good scientific information on stock status and exploitation rates are required to inform sustainable management of this resource.

Nephrops spend a great deal of time in their burrows and their emergence behaviour is influenced by several factors: time of year, light intensity, tidal strength, etc. Underwater television surveys and assessment methodologies have been developed to provide a fishery independent estimate of stock size, exploitation status and catch advice (ICES, 2009a & 2013).

This is the seventeenth annual UWTV survey of the 'Aran grounds'. The survey covers three geographically discrete mud patches; the Aran Ground, Galway Bay and Slyne Head all of which lie within the ICES assessment area Functional Unit 17 (Figure 1). The 2018 survey was multi-disciplinary in nature; the specific objectives are listed below:

1. To complete a survey of 33 UWTV randomised fixed isometric grid stations, with 3.5 nautical mile (Nmi) spacing on the "Aran" *Nephrops* ground.
2. To carry out ≥ 5 UWTV indicator stations on the Galway Bay and Slyne Head *Nephrops* ground.
3. To obtain 2018 quality assured estimates of *Nephrops* burrow distribution and abundance on the "Aran" *Nephrops* ground (FU17). These will be compared with those collected previously.
4. To collect ancillary information from the UWTV footage collected at each station such as the occurrence of sea-pens, other macro benthos and fish species and trawl marks on the sea bed.
5. To collect oceanographic data using a sledge mounted CTD.
6. To sample *Nephrops* and macro benthos using a 4 m beam trawl deployed at ~10 stations.

This report details the final UWTV results of the 2018 survey and also documents other data collected during the survey. Operational survey details are available in form of a survey narrative from the scientist in charge (JD). The 2018 abundance are used to generate catch options for 2019 in line with the recommendations and procedures outlined in the stock annex for FU17 (ICES, 2015).

Material and methods

Since 2012 the Aran survey design has been based a randomised isometric grid with stations every 3.5 Nmi or 6.5km. This spacing was used to achieve good spatial coverage over the

known extent of the ground and to generate a burrow surface that reflect the underlying abundance. The randomised grid and random stations on the Galway Bay and Slyne grounds were generated using the "spsampl" function in the "sp" package (Pebesma & Bivand, 2005) of "R" (R Core Team, 2017). The ground boundary used for the Aran, Galway Bay and Slyne grounds was revised by an ICES inter-benchmark process (ICES, 2015). In the past stations in Galway Bay and Slyne Head were randomly picked from an area defined by previously collected UWTV data, VMS data (Gerritsen & Lordan, 2011) and multi-beam backscatter data (Figure 1 & 2). Not all stations completed in 2018 and in previous years fell within the polygons demarking the defined grounds and these were excluded from the analysis.

Survey timing was generally standardised to June each year. In 2003, poor weather and technical problems meant that coverage was poor compared with the other years. In 2004, bad weather prevented the completion of the survey in June so approximately 50% of the stations were carried out one month later in July. In 2003 and 2008 due to weather downtime stations could not be completed at Slyne Head. In 2015 the Galway Bay and 14 Aran stations were surveyed on June 10th and 11th on RV Celtic Voyager. The vessel then broke down and the remaining stations (20 Aran and 5 Slyne) were carried out on RV Prince Madog on the 1st and 2nd of July. This year's survey took place between the 19th and 26th of June.

The operational protocols used were those reviewed by WKNEPHTV 2007 (ICES, 2007) and employed on other UWTV surveys in Irish waters. They can be summarised as follows: At each station the UWTV sledge was deployed. Once stable on the seabed a 10 minute tow was recorded onto DVD. Time referenced video footage was collected by one video camera with a field of view or 'FOV' of 75 cm. Vessel position (DGPS) and position of sledge (using a USBL transponder) were recorded every 2 seconds. The navigational data was quality controlled using an "R" script developed by the Marine Institute (ICES, 2009b) an example is shown in Figure 3. In 2018 the USBL navigational data was used to calculate distance over ground for 95% stations. For one station in the Aran grounds and one in Galway Bay, corrected ship navigation data was used.

In line with recommendations of the Study Group on *Nephrops* Surveys (SGNEPS), all scientists were trained/re-familiarised using training material and validated using reference footage for the Aran Grounds, with counts validated, prior to counting at sea (ICES, 2009b). Individual's counting performance in 2018 against the reference footage was measured by Lin's concordance correlation coefficient (CCC). A threshold of 0.5 was used to identify counters who needed further training. Once this training and testing process had been undertaken, all counts were conducted by two scientists independent of each other on board the research vessel during the survey. During this review process the visibility, ground type and speed of the sledge during one-minute intervals were subjectively classified using a classification key. In addition, the numbers of *Nephrops* burrows complexes (multiple burrows in close proximity which appear to be part of a single complex which are only counted once), *Nephrops* activity in and out of burrows were counted and recorded for each one-minute interval. Following the recommendation of SGNEPS the time for verified recounts was 7 minutes (ICES, 2009b).

The occurrence of trawl marks, fish species and other species was also recorded for each minute. Abundance categories of sea-pen species were also recorded due to OSPAR Special Request (ICES 2011). A key was devised to categorise the densities of sea-pens based on SACFOR abundance scale (Table 2) after ICES (2011). Finally, if there was any time during the one-minute where counting was not possible, due to sediment clouds or other reasons, this was also estimated so that the time window could be removed from the distance over ground calculations.

In 2018 the survey count data were screened to check for any unusual discrepancies using Lin's Concordance Correlation Coefficient (CCC) with a threshold of 0.6. Lin's CCC (Lin, 1989) measures the ability of counters to exactly reproduce each other's counts on a scale of 1 to –1 where 1 is perfect concordance (i.e. a pairwise plot will have all points lying along the 1:1 line; a value of –1 would be generated by all points lying on the –1:1 line and a value of 0 indicates no correspondence at all). Lin's CCC quality control plot of survey count data for stations 1 to 3 is shown in Figure 4.

Mean density was calculated by dividing the total number of burrow systems by the survey area observed. The field of view of the camera at the bottom of the screen was estimated at 75cm assuming that the sledge was flat on the seabed (i.e. no sinking). This field of view was confirmed using lasers during the 2018 survey. Occasionally the lasers were not visible at the bottom of the screen due to sinking in very soft mud, the impact of this is a minor under estimate of densities at stations where this occurred.

To account for the spatial co-variance and other spatial structuring a geo-statistical analysis of the mean and variance was carried out with the "R" package, "RGeostats" 10.0.8 (Renard D. et al., 2015). The procedure used is fully documented in the stock annex.

To estimate the abundance for Galway Bay and Slyne Head grounds, the area of each ground polygon was calculated in ArcGIS10 and an average value used (Table 1). The abundance estimation is the product of the mean density and ground area. The sample variances, standard errors, t-values and 95% CI were calculated for each ground.

For each UWTV station a CTD profile was logged for the duration of each tow using a sled mounted and calibrated Seabird SBE37. This data will be processed at a later stage.

Eight beam trawl tows were conducted randomly across the Aran grounds once TV operations were successfully completed. All *Nephrops* caught were sorted by sex and maturity category, weighed and measured using the NEMESYS electronic measuring system. A length stratified sub-sample of *Nephrops* was taken for each haul where individual length, whole weight, tail weight and maturity were recorded. The fish catch were identified to species level and sampled by weight (kgs) only. Catch of other benthos was identified, weighed (g) and counted. The UWTV station positions and tracks for the 10 valid beam trawl tows are shown in Figure 2.

Results

The station positions for the 33 stations on the Aran grounds, 5 in Galway Bay and 5 at Slyne head are shown in Figure 2. One further station was carried out in Galway Bay on the zero grounds and is not used in the analysis. A combined violin and box plot of the observed burrow densities from 2006 to 2017 is presented in Figure 5. This shows relatively large inter-annual variation in mean, median and density ranges over time. Density increased in first three years of the time series but then declined significantly in 2006. Since then there has been a gradual downward trend. The mean and median density has increased in 2018 to levels observed in 2015. It has been very noticeable since 2011 that there was a substantial reduction in density throughout the ground with no high density (> 0.7/m^2) observed. Figure 6 shows the variability in density between minutes and operators (counters) for each station. These show that the burrow estimates are fairly consistent between minutes and counters.

Combined krigged contour plots and bubble plots of density data from 2002 to 2018 are shown in Figure 7. These show that densities have fluctuated considerably over the time series and throughout the ground. The fluctuations are not limited to a single station but instead occur fairly homogeneously across the ground. In general, the densities are higher towards the western side of the ground and there is a notable trend towards lower densities towards the east. On the south western boundary there are often high densities close to the boundary. In this area there is a sharp transition from mud to rocky substrate. The densities in 2018 were fairly homogenous throughout the ground.

The summary statistics from this geo-statistical analysis for the Aran Grounds are given in Table 3 and Figure 8. The 2018 abundance estimate of 488 million burrows is a 30% higher than in 2017. The estimation variance of the surveys is relatively low (CVs in the order <6%).

The summary statistics for the stations on Slyne head and in Galway Bay are given in Table 4. The abundance estimates for Galway Bay *Nephrops* ground and for Slyne Head *Nephrops* ground also are shown in Figure 8. The Galway Bay estimates fluctuate widely but appear to be highly correlated with the Aran ground (except 2004). Estimates for the Slyne Head ground also fluctuate considerably but show no significant correlation with the other areas. The uncertainty bounds for these areas also fluctuate and inter-annual changes are only statistically significant in a few years. On average the Aran Grounds account for ~88% of the total estimated burrow abundance from FU17. Galway Bay and Slyne Head account for ~8% and ~2% respectively. The 2018 combined abundance estimate was 27% higher than in 2017 and at 554 million is above MSY $B_{trigger}$ value of 540 million (Table 5 and Figure 9).

Figure 10 shows the standardised length frequency distributions (LFDs) by sex of *Nephrops* caught using a beam trawl on the Aran grounds between 2006 and 2018 surveys. No fishing was carried out on surveys prior to 2006 or in 2008 and 2015 (due to time constraints as a result of poor weather conditions). For plotting purposes the individuals <10 CL mm caught in 2010 and 2017 were split evenly between males and females as it is not possible to accurately assign sex to individuals that small. There is weak indication of a year class signal in 2010 and 2017 but few individuals less than 20 CL mm in most years. The mean lengths for both sexes show an increasing trend over time.

A summary of the benthic taxa by tow is presented in Figure 11. This heatmap combined with a dendrogram shows the proportional counts of benthic species. A threshold was used which removed those species with less than 1% as their maximum relative abundance. Hierarchical clustering using the complete linkage method with Euclidean distance measure identifies stations which have similar benthic compositions. *Lunatia species* (necklace shell) was the most abundant species. *Eledone cirrhosa* (curled octopus) was also recorded where this species is a noted predator of crustaceans and has been observed lying close to the *Nephrops* burrow entrances on the Smalls ground (FU22). Table 6 summarises the fish catches. The most abundant fish species recorded were; *Lepidorhombus whiffiagonis* (megrim), *Glyptocephalus cynoglossus* (witch) and *Lophius budegassa* (black-bellied monkfish).

The sea-pen presence-absence observations across the *Nephrops* grounds are mapped in Figure 12 using the key described in Table 2. All of sea-pens were identified from the video footage as *Virgularia mirabilis* and was also present at stations where trawl marks were recorded. Trawl marks were noted at 20% of the Aran stations surveyed. Trawl marks were also present at one station at Slyne Head and Galway Bay.

The UWTV abundance data together with data from the fishery; landings, discards and removals in number are used to calculate the harvest rate in 2017 of 4.0%. The mean weight in the landings and the discards and the proportions of removal retained are shown in Table 7.

The input variables for catch scenarios are given in Table 7. The catch and landings scenarios at various different fishing mortalities are calculated in line with the stock annex using the 2018 survey abundance are presented in Table 8. The latest estimate of stock abundance (value from June 2018 survey, 554 million) is above the MSY $B_{trigger}$ value (540 million). Fishing at MSY approach in 2019 would result in catches of 1002 t and wanted catch of 916 t assuming that discard rates and fishery selection patterns do not change from the average of 2015–2017 (Table 9).

Discussion

Observed burrow densities have fluctuated a lot over time in this area. The abundance shows an overall decreasing trend over time and has been at or below MSY $B_{trigger}$ since 2012. This is in contrast to the more stable burrow abundance estimates in most other *Nephrops* grounds in ICES Sub-area 7 over similar time frames.

Discard rates in weights for this FU are estimated to have reduced significantly in the in the last five years and are now estimated at around 8% by weight (mean 2015:2018). *Nephrops* fisheries in this area have been covered under the landings obligation since 2016 and a *de minimis* exemption is also in place allowing up to 6% of the catch to be discarded in 2018. The provision of catch advice and scenarios for 2019 based on the MSY approach assumes that discard rates and fishery selection patterns do not change from the average of 2015–2017.

The imposition of the landings obligation on *Nephrops* fisheries since 2016 should result in changes in selectivity. This is not taken into account in any of the catch advice because it is not possible to predict exactly what might happen. The main message is that any improvements in selectivity in the fishery and reductions in discards will result in increased mean weight in the catches. This will in turn reduce overall mortality on the stocks and allow for catch increases in the future.

An important objective of this UWTV survey is to collect ancillary information. The occurrence of trawl marks on the footage is notable for two reasons. Firstly, it makes identification of *Nephrops* burrows more difficult as the trawl marks remove some signature features making accurate burrow identification more difficult. Secondly, only occupied *Nephrops* burrows will persist in heavily trawled grounds and it is assumed that each burrow is occupied by one individual *Nephrops* (ICES 2009b).

The CTD data collected during the survey will augment the knowledge base on habitat and oceanographic regime.

Monitoring the occurrence and frequency of sea-pens observed on these *Nephrops* patches is important in the context of OSPAR's designations of sea-pen and burrowing megafauna communities as threatened. The sea-pen species *Virgularia mirabilis* which was seen in 2018 have been observed on previous surveys of FU17. Monitoring *Nephrops* stock and the benthic habitat is also important in the context of the MSFD indicators (e.g. sea floor integrity).

The main objectives of the survey were successfully met for the seventeenth successive year. The UWTV coverage and footage quality was excellent throughout the survey. The multi-disciplinary nature of the survey means that the information collected is highly relevant for a number of research and advisory applications.

Acknowledgments

We would like to express our thanks and gratitude to Philip Baugh (Master) and crew of the RV. Celtic Voyager for their good will and professionalism throughout the survey. Thanks also to Marc O'Connor P&O Maritime IT & Instrumentation Technician**,** for handling all onboard technical difficulties. Thanks to Aodhan Fitzgerald, Rosemarie Butler(RVOPs) and Rob Bunn and Dave Tully (FEAS) at the Marine Institute for organising survey logistics. Thanks also to Gordon Furey, Barry Kavanagh, John Barry and Tom O'Leary P&O Maritime for shore side support.

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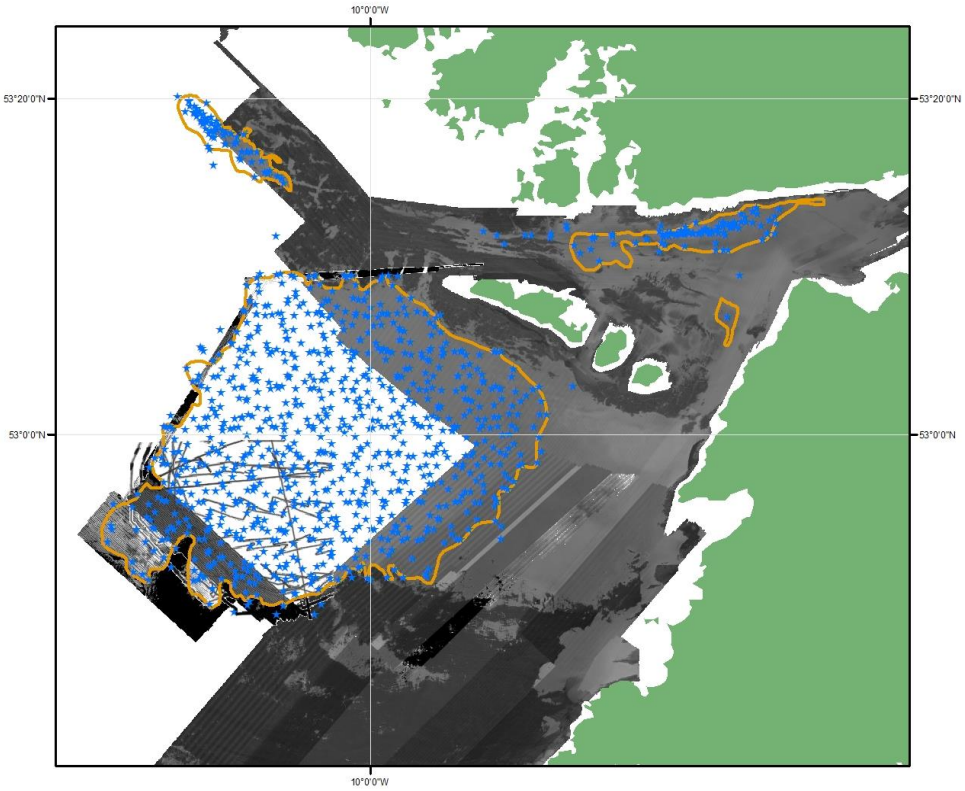


Figure 1: The spatial distribution of all UWTV survey stations from 2002-2018 in Functional Unit 17 overlaid on multibeam backscatter data (source: INFOMAR 2005-2016). Darker grey backscatter indicates harder seabed substrate.

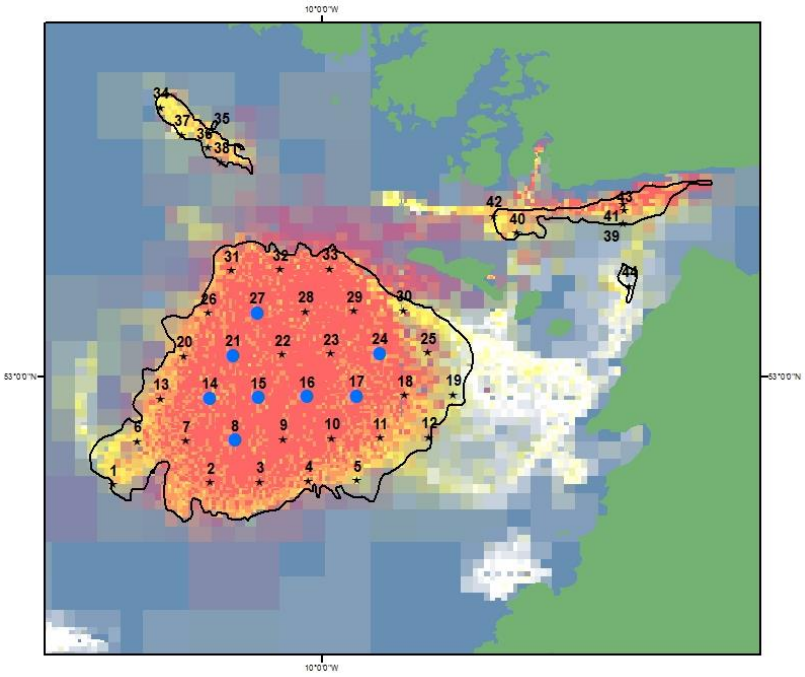


Figure 2: FU17 Aran grounds: UWTV Stations completed in 2018 overlaid on a heat map of *Nephrops* directed fishing activity between 2006 -2017. (*) denotes TV stations and blue dots beam trawl stations.

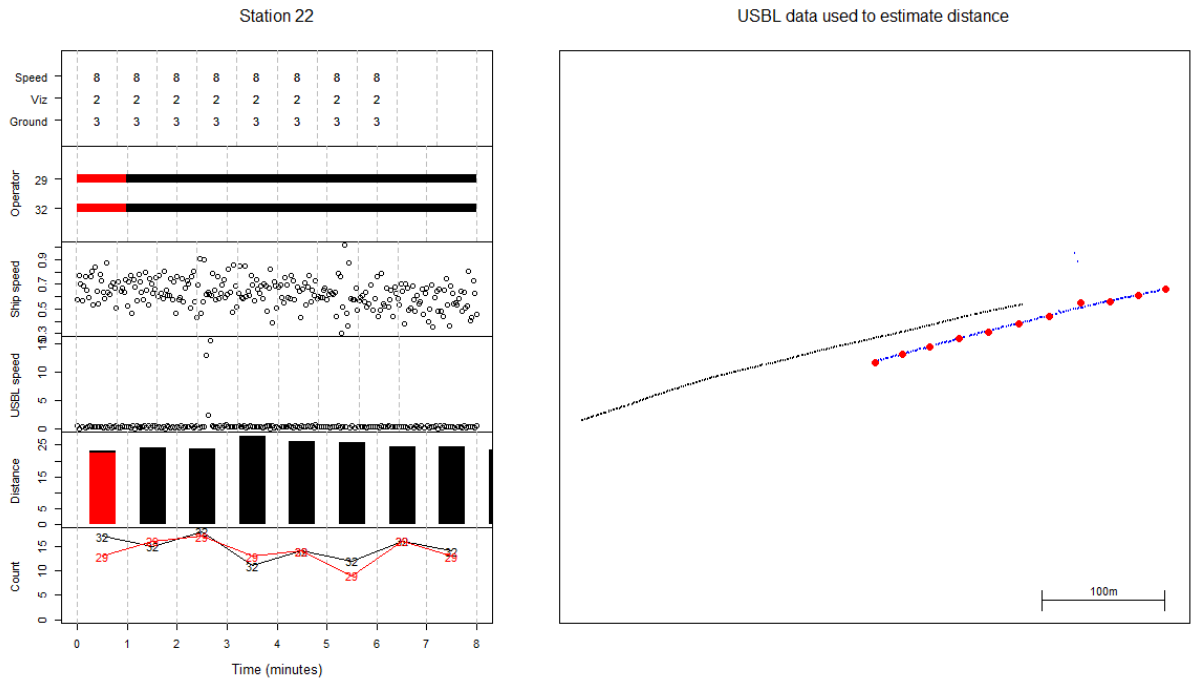


Figure 3 : FU17 Aran grounds: R - tool quality control plot of station 22 of the 2018 survey.

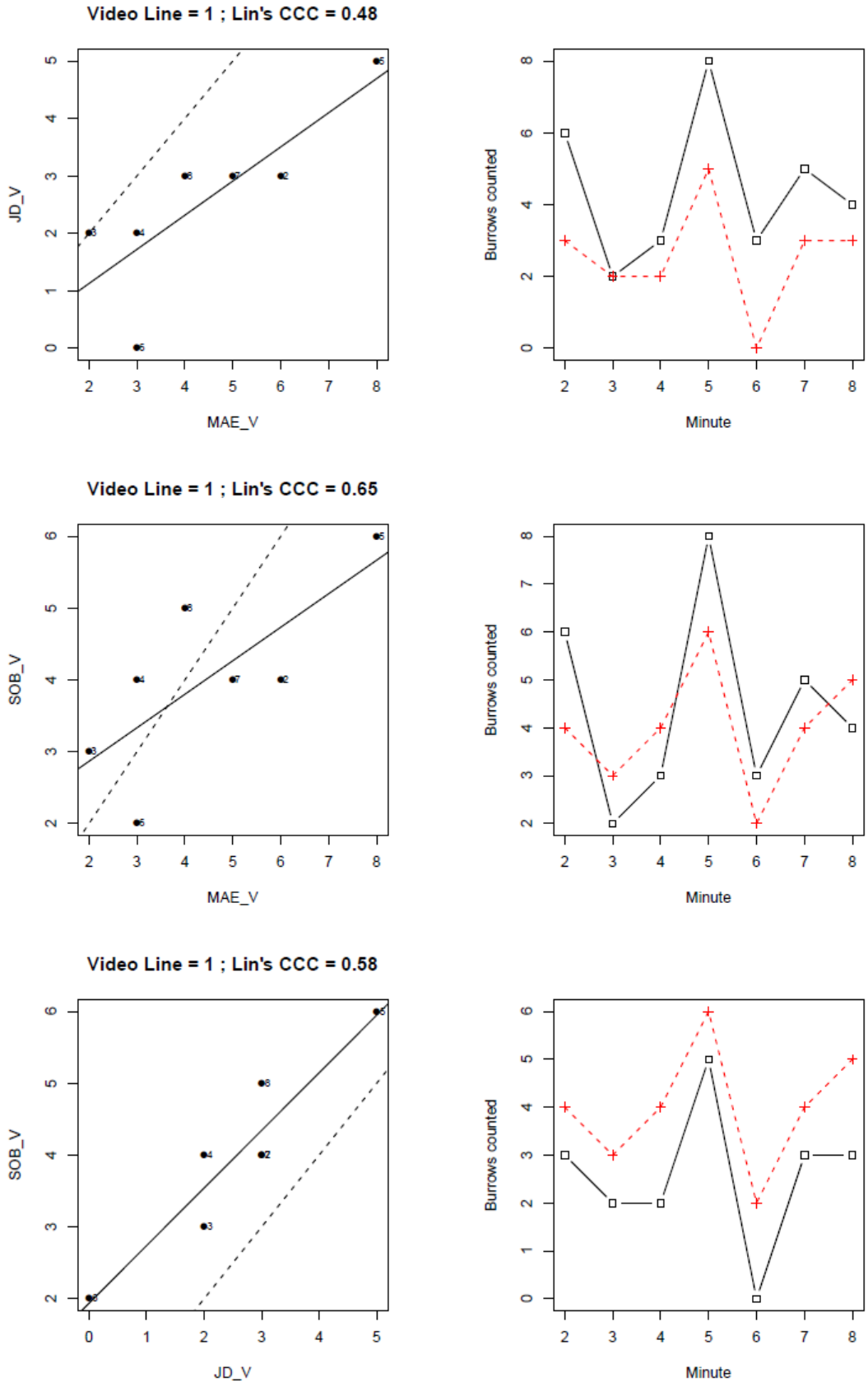


Figure 4: FU17 Aran grounds: Lin's CCC quality control plot of count data for stations 1 – 3 of the 2018 survey.

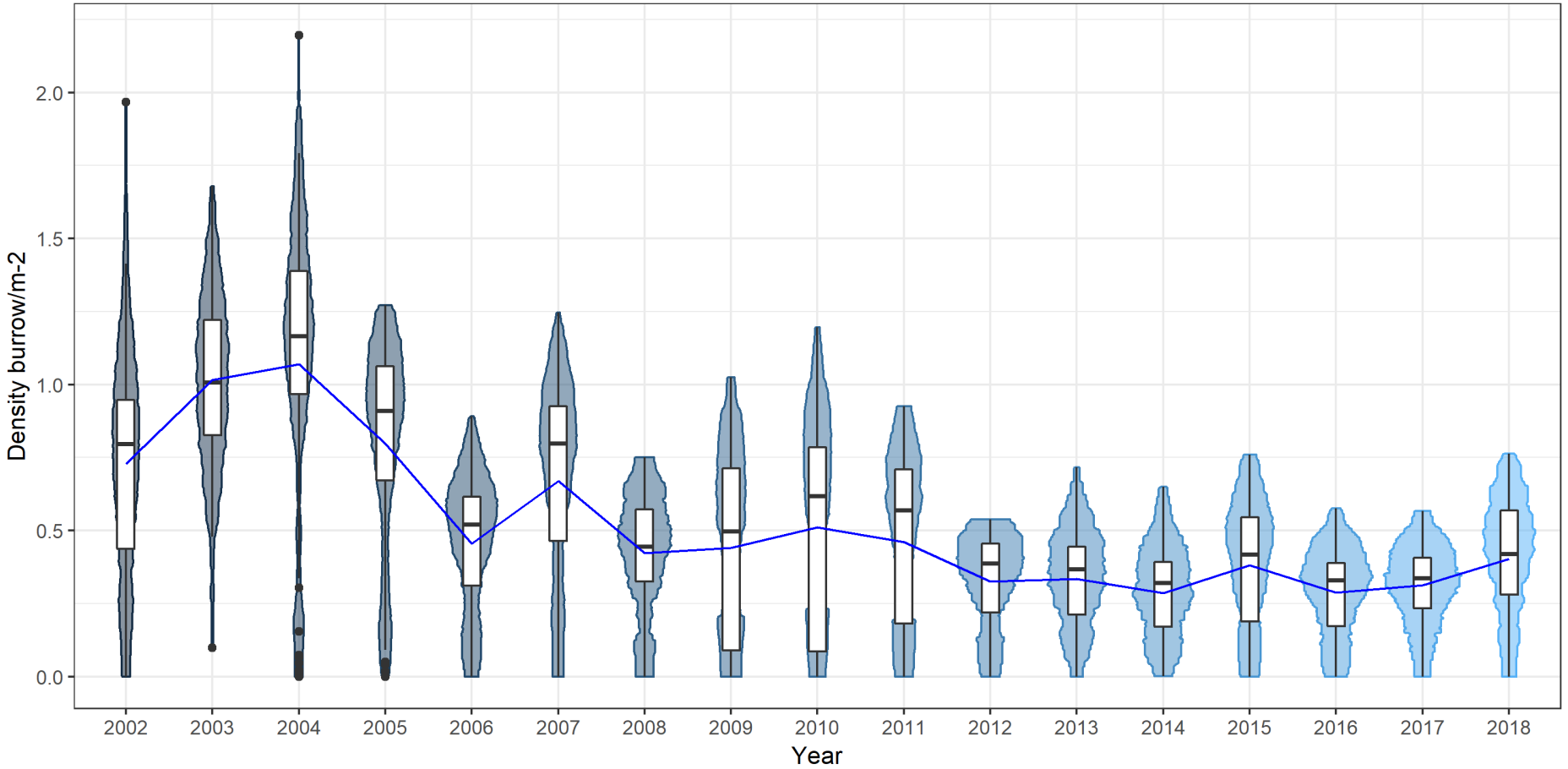
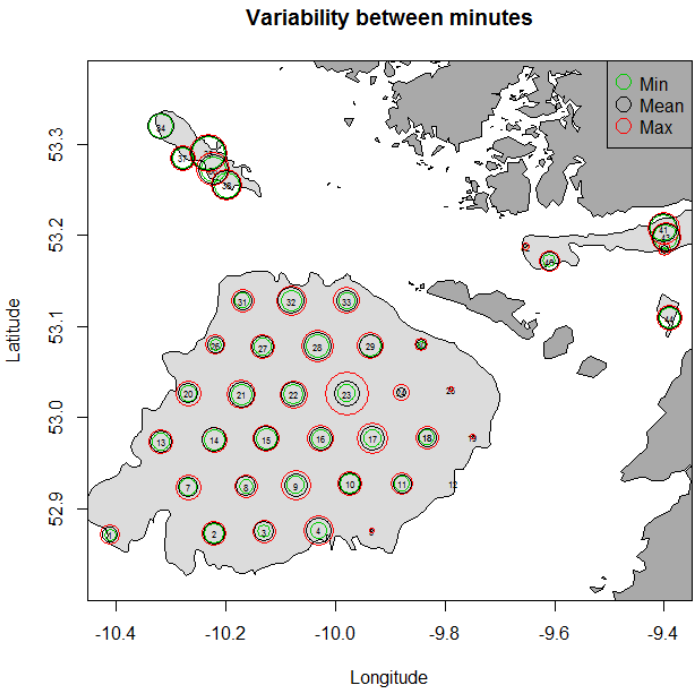


Figure 5: FU17 Aran grounds: Violin and box plot of adjusted burrow density distributions by year from 2006-2018. The blue line indicates the mean density over time. The horizontal black line represents the median, white box is the inter quartile range, the black vertical line is the range and the black dots are outliers.



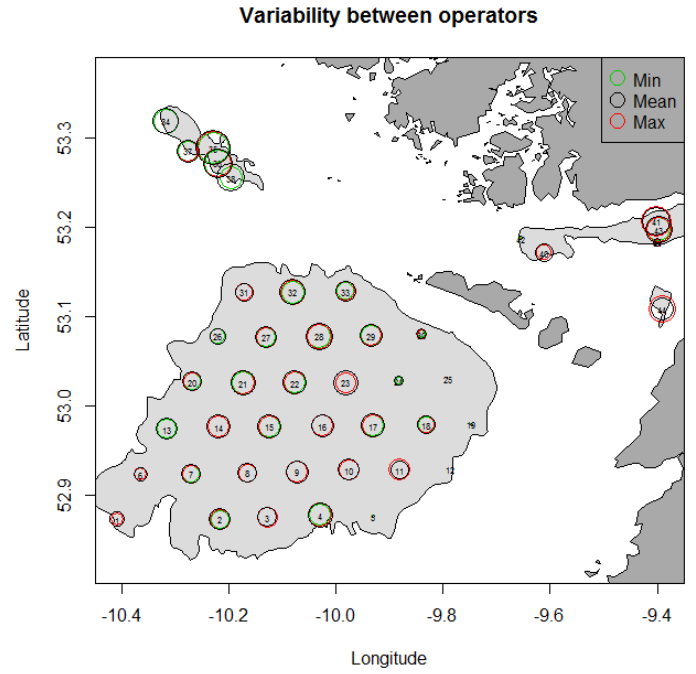


Figure 6: FU17 Aran grounds: Plot of the variability in density between minutes (top panel) and between operators (counters) (bottom panel) for each station in 2018.

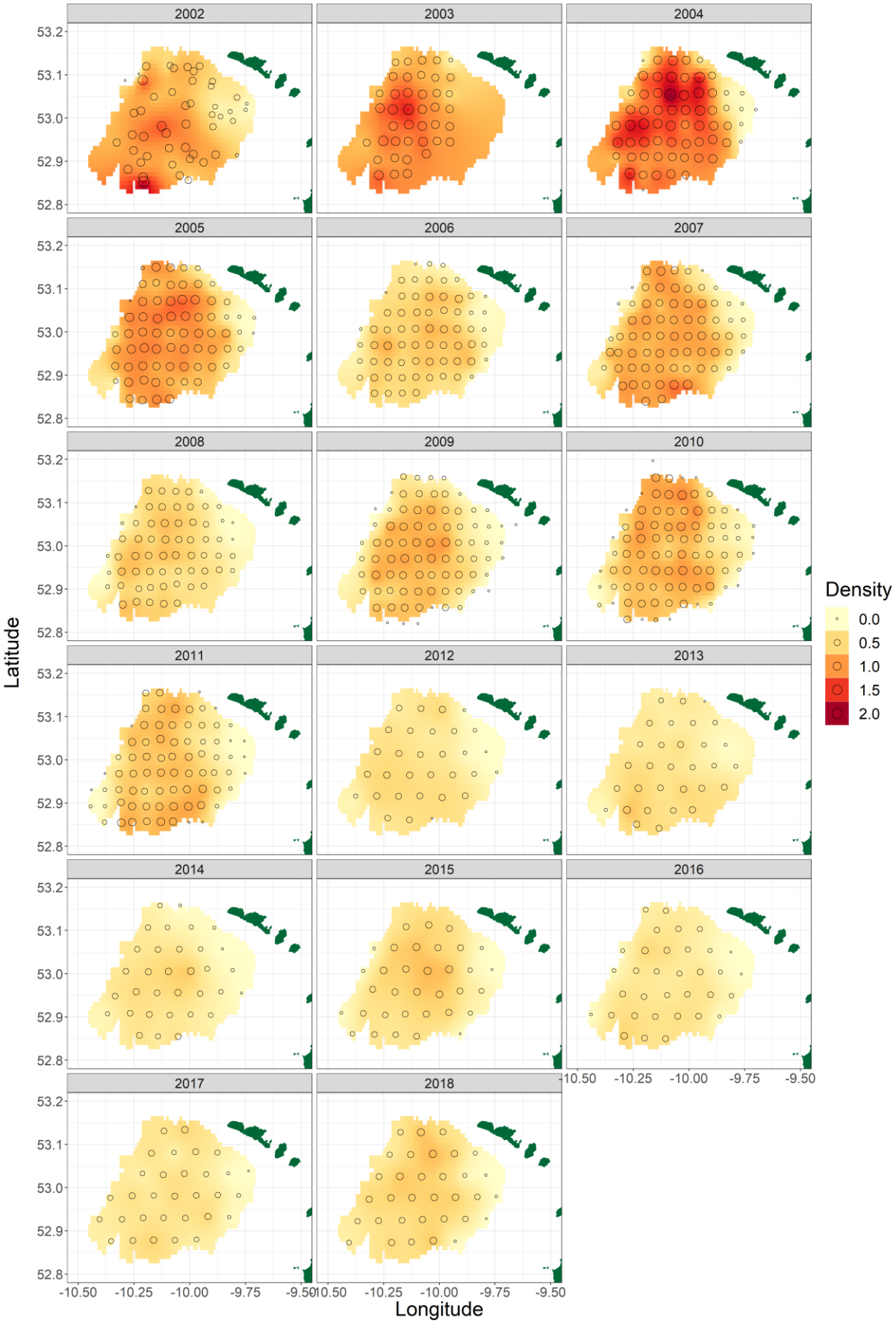


Figure 7: FU17 Aran grounds: Contour plots of the krigged density estimates by year from 2002 (top left) - 2018 (bottom).

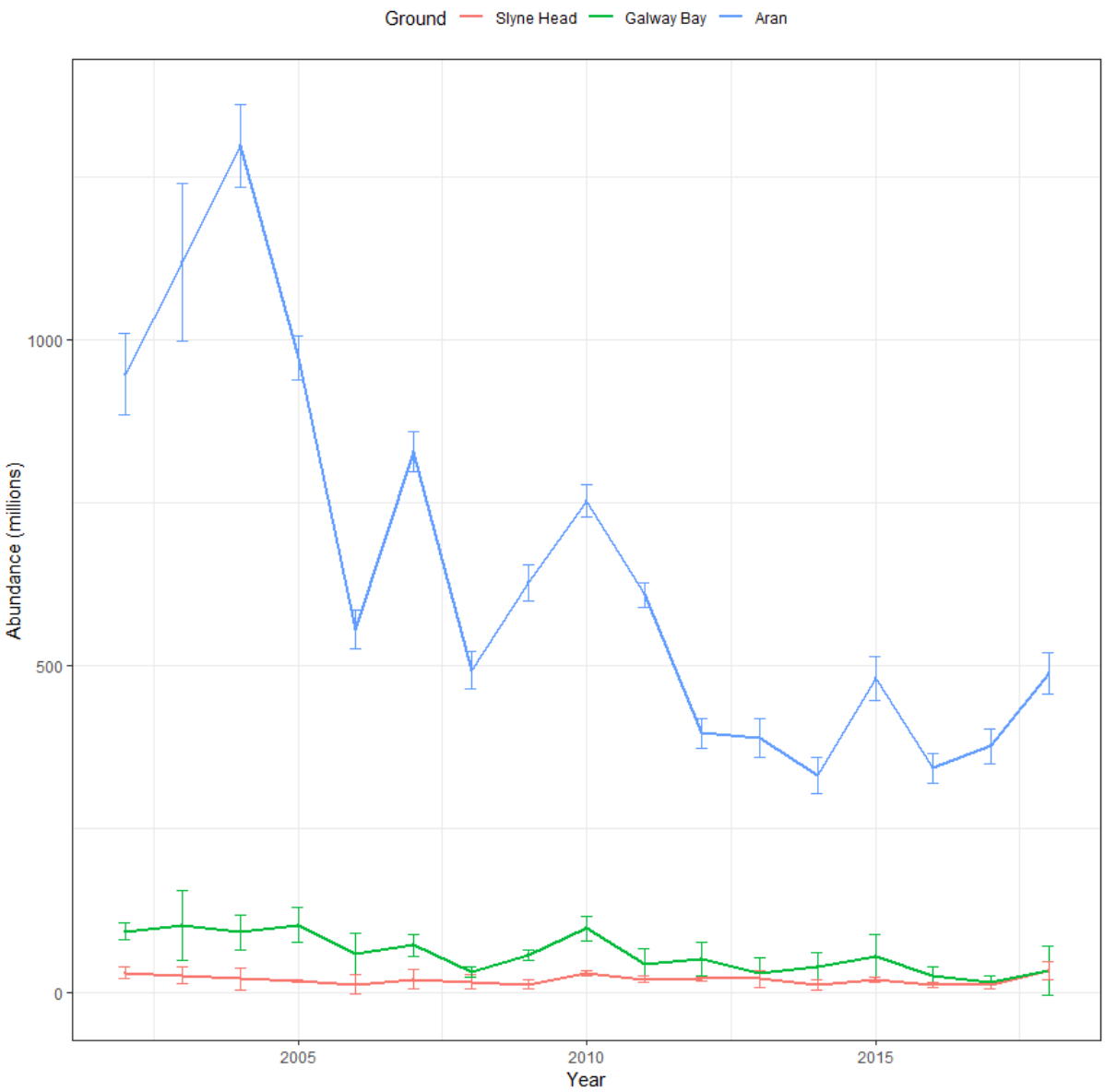


Figure 8: FU17 Aran grounds: Time series of abundance estimates for the Aran Grounds, Galway Bay and Slyne Head (error bars indicate 95% confidence intervals).

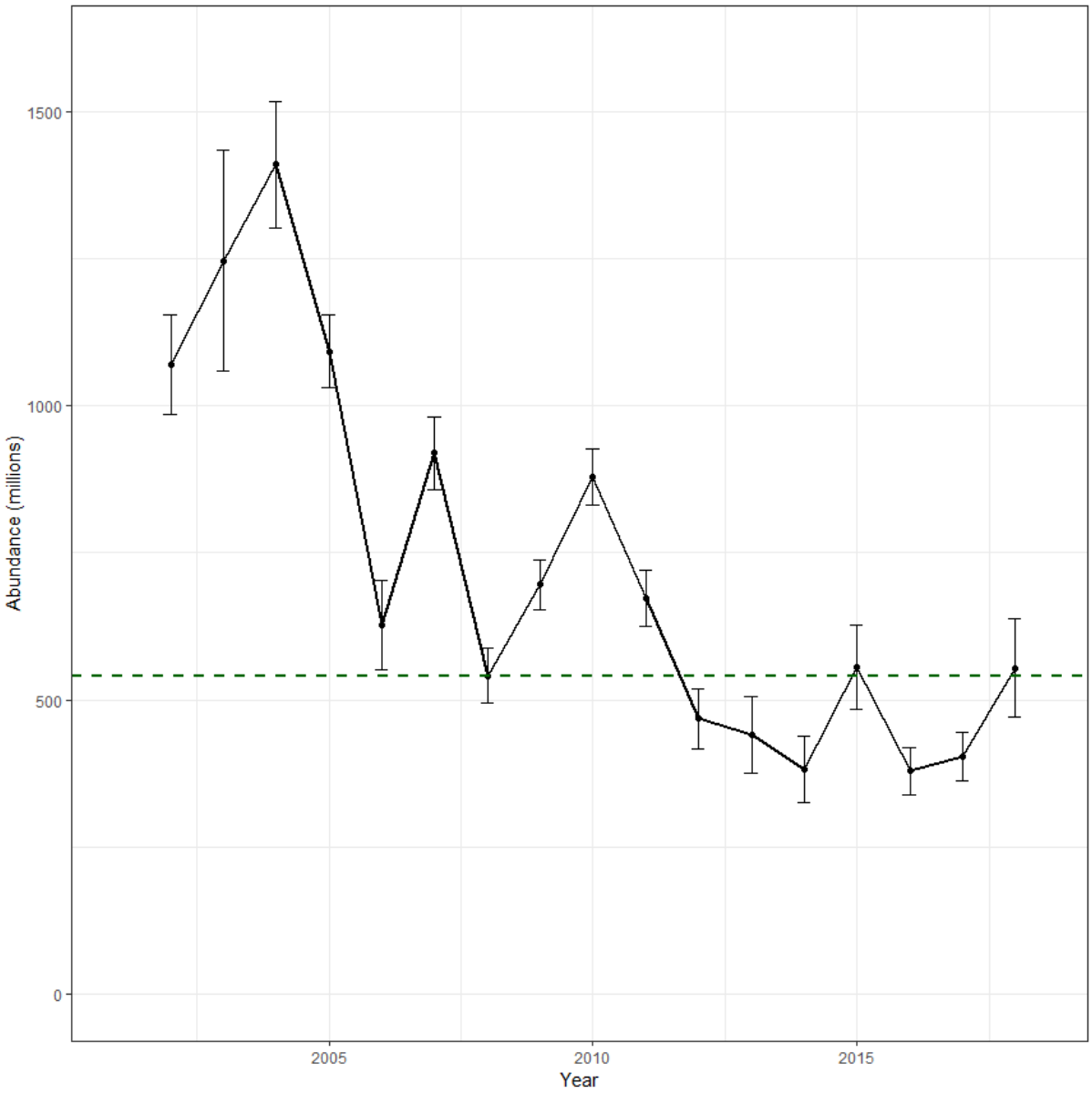


Figure 9: FU17 Aran grounds: Time series of total abundance estimates for FU17 (error bars indicate 95% confidence intervals) and $B_{trigger}$ (540 million) is dashed green line.

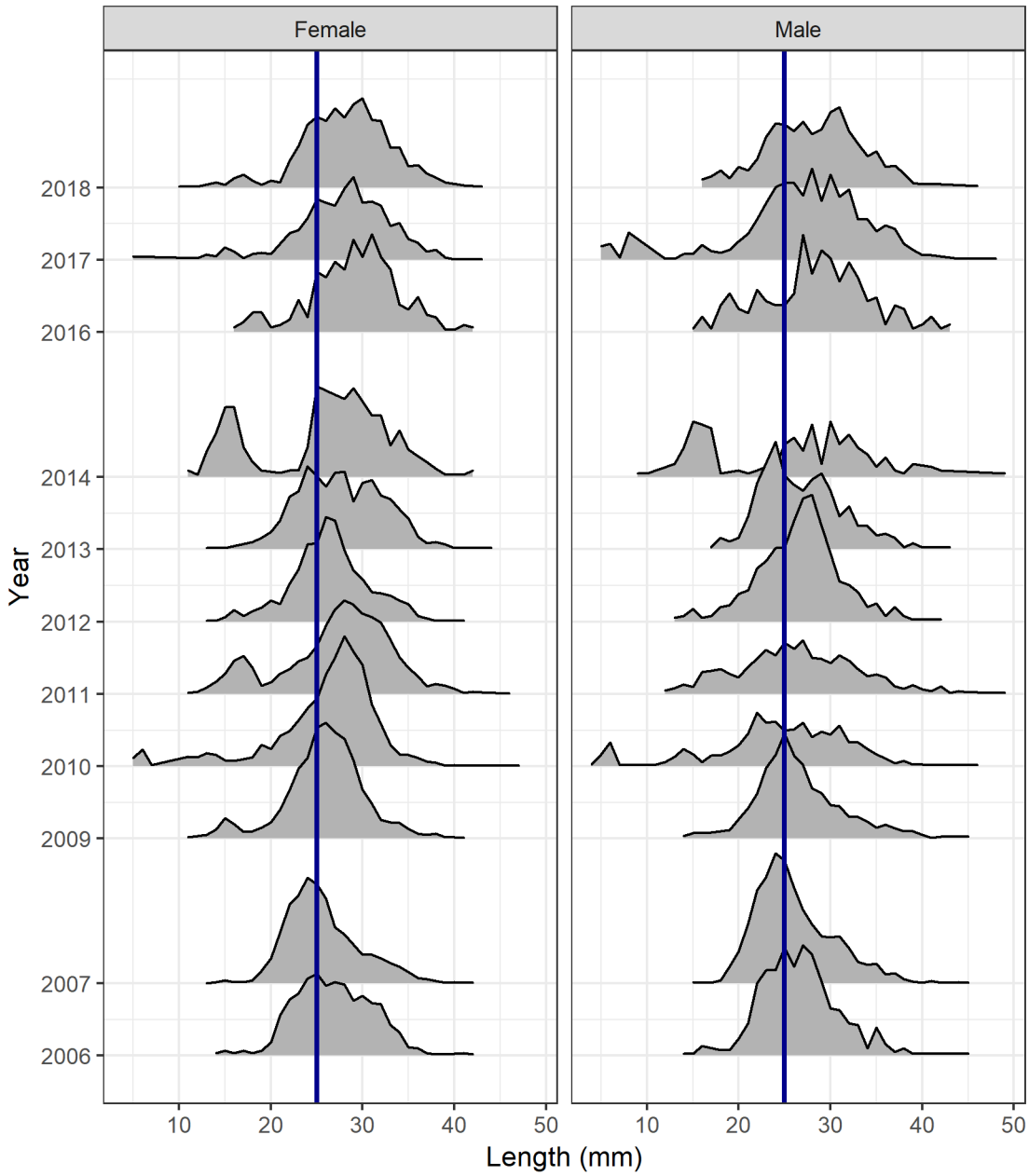


Figure 10: FU17 Aran grounds: Standardised length frequency distributions for male and female *Nephrops* caught using beam trawl during 2006 to 2018 UWTV surveys on the "Aran Grounds" except years 2008 and 2015. Minimum conservation reference size (MCRS) 25 mm carapace length shown as blue line.

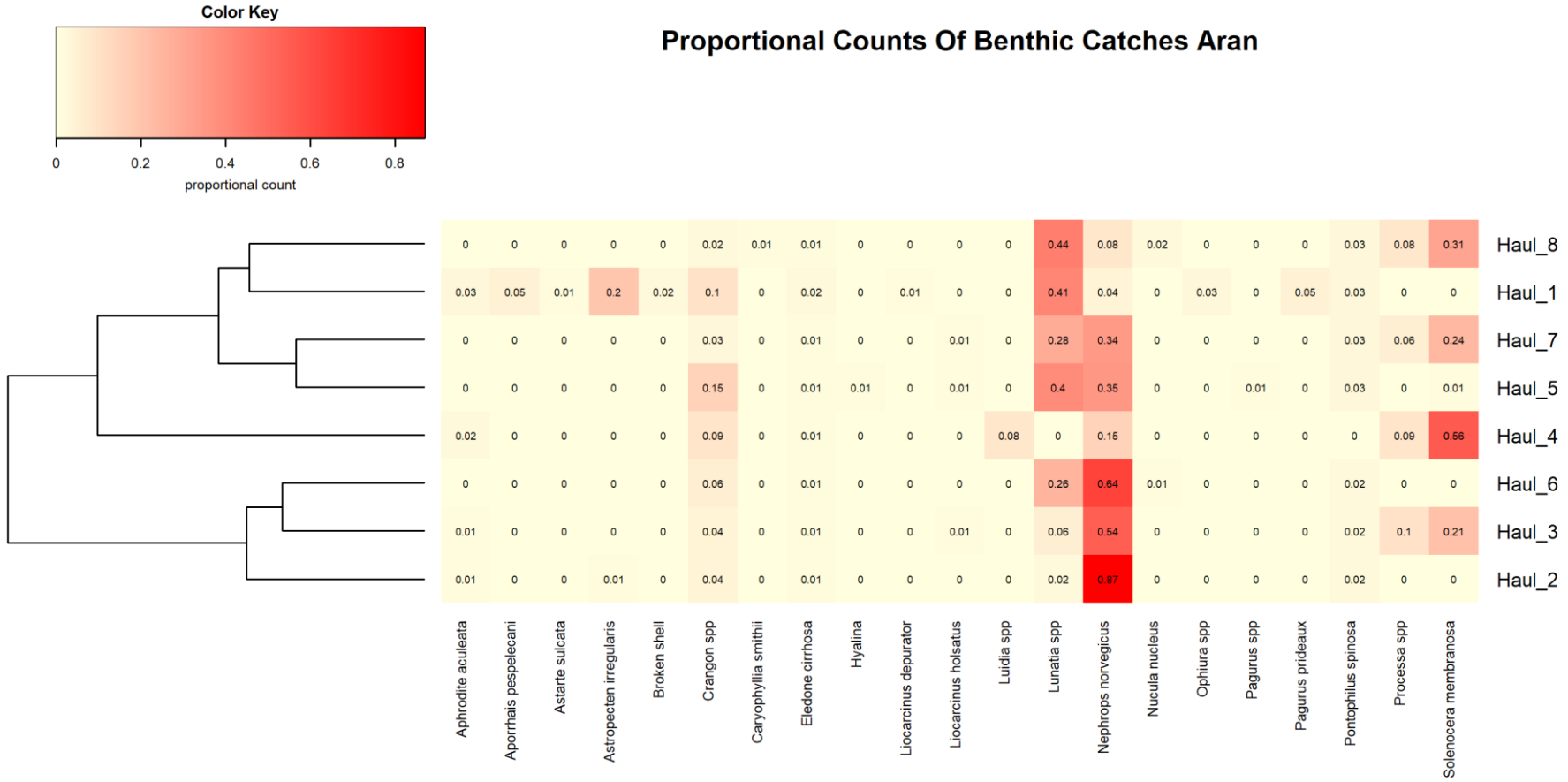


Figure 11: FU17 Aran grounds: Heat map and dendrogram of benthic catches from 2018 beam tows.

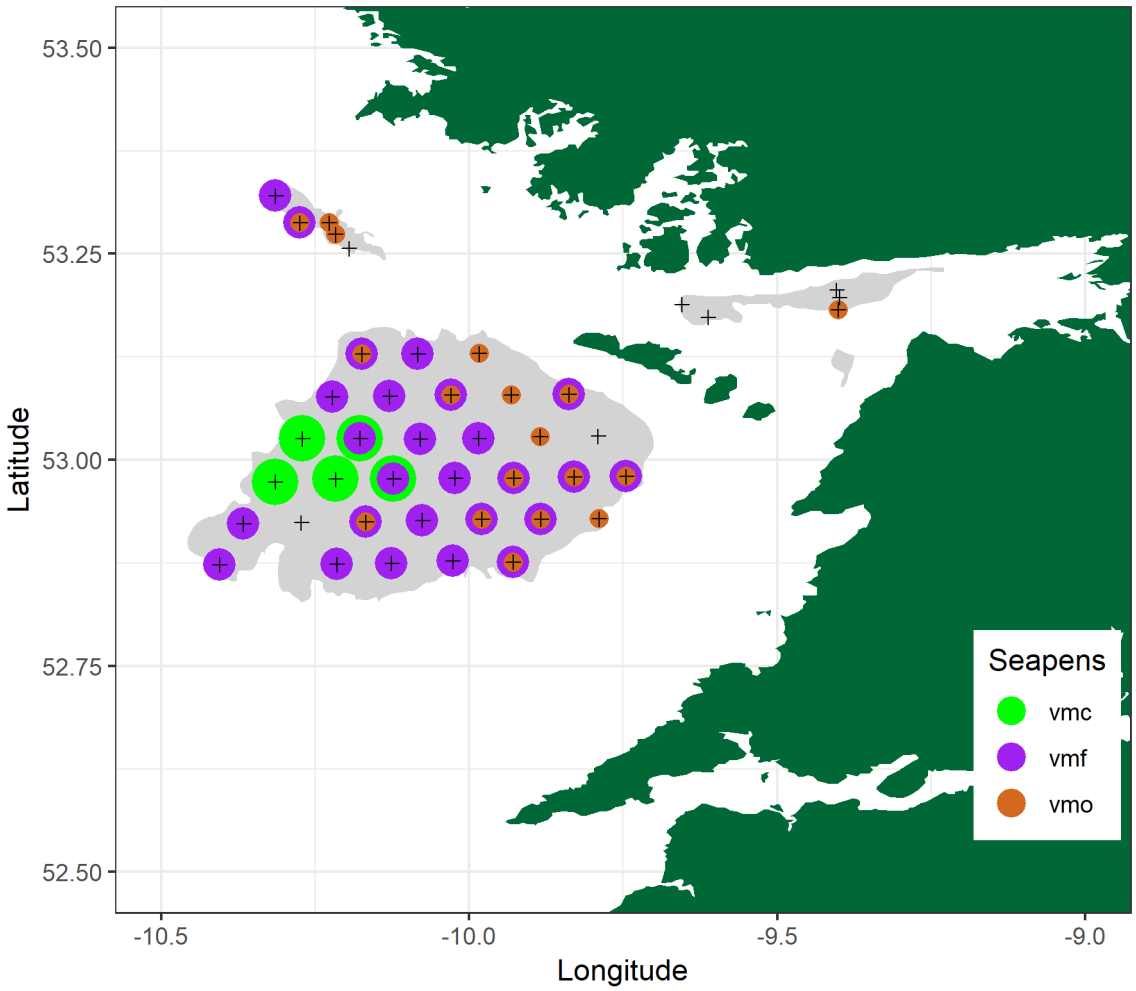


Figure 12: FU17 Aran grounds: 2018 stations where *Virgularia mirabilis* (vm) were identified from video footage and classified according to abundance key - occasional (o), frequent (f), common (c). (+) denotes TV stations with no sea-pen observations.

Table 1: FU17 Aran grounds: Area calculations for Aran grounds, Galway Bay and Slyne Head *Nephrops* grounds in ArcGIS10.

Ground	Area (km²)
Aran	1202
Galway Bay	79
Slyne Head	39.1
Total	1320.1

Table 2: Key for classification of seapen abundance as used on Irish UWTV surveys.

	Number/Min
Common	20-200
Frequent	2-19
Ocasional	<2

	Sea Pens								
	V. mirabilis			*P. phosphorea*			*F. quadrangularis*		
Species	C	F	O	C	F	O	C	F	O
Virgularia mirabilis									
Pennatula phosphorea									
Funiculina quadrangularis									

Table 3: FU17 Aran grounds: Overview Aran of geostatistical results from 2002-2018.

Year	Number of Stations	Mean Density (burrows/m²)	Estimation Standard Deviation	Area (km²)	Geostatistical abundance estimate (millions of Burrows)	CV on Burrow estimate %
2002	49	0.79	0.17	1196	947	3
2003	41	0.94	0.09	1196	1118	6
2004	64	1.08	0.27	1196	1297	3
2005	70	0.81	0.12	1196	972	2
2006	67	0.46	0.06	1196	556	3
2007	71	0.69	0.12	1196	828	2
2008	63	0.41	0.05	1196	494	3
2009	82	0.52	0.1	1196	627	2
2010	87	0.63	0.1	1196	752	2
2011	76	0.51	0.09	1196	609	2
2012	31*	0.33	0.03	1196	397	3
2013	31*	0.33	0.03	1196	390	4
2014	33*	0.28	0.03	1196	332	4
2015	34*	0.40	0.06	1197	480	4
2016	34*	0.29	0.03	1196	343	3
2017	31*	0.31	0.02	1196	377	4
2018	33*	0.40	0.05	1196	488	3

* Reduced isometric grid

Table 4: FU17 Aran grounds: Summary statistics for the Galway Bay and Slyne Head *Nephrops* grounds from 2002-2018.

Year	Ground	Number of stations	Mean Adjusted Density (burrow/m²)	CViid (Relative SE) %	Area (km²)	Raised abundance estimate (million burrows)	Upper CI on abundance	Lower CI on abundance
2002	Galway Bay	7	1.18	7	78.966	93.1	105.9	80.3
2003	Galway Bay	3	1.3	16	78.966	102.6	155.7	49.6
2004	Galway Bay	8	1.17	14	78.966	92.2	119.1	65.3
2005	Galway Bay	4	1.3	11	78.966	103	130	76
2006	Galway Bay	3	0.74	9	78.966	58.8	90.4	27.2
2007	Galway Bay	5	0.91	8	78.966	71.8	89	54.6
2008	Galway Bay	5	0.4	4	78.966	31.6	39.9	23.3
2009	Galway Bay	8	0.71	4	78.966	56.3	64.6	48
2010	Galway Bay	10	1.24	11	78.966	97.6	116.5	78.7
2011	Galway Bay	6	0.55	12	78.966	43.2	67.1	19.4
2012	Galway Bay	4	0.64	10	78.966	50.9	76.9	24.9
2013	Galway Bay	5	0.37	10	78.966	29.6	52	7.2
2014	Galway Bay	3	0.5	6	78.966	39.8	60.6	19
2015	Galway Bay	5	0.71	15	78.966	55.8	88.8	22.8
2016	Galway Bay	7	0.32	7	78.966	25.1	41.8	8.4
2017	Galway Bay	5	0.20	4	78.966	15.8	25.4	6.1
2018	Galway Bay	5	0.41	17	78.966	32.5	70.5	-5.5
2002	Slyne Head	5	0.76	8	39.146	29.8	38.9	20.7
2003*	Slyne Head	0	0.65	0	39.146	25.3	38.1	12.4
2004	Slyne Head	3	0.53	10	39.146	20.8	37.4	4.2
2005	Slyne Head	3	0.44	1	39.146	17.4	18.6	16.2
2006	Slyne Head	3	0.3	9	39.146	11.8	26.3	-2.6
2007	Slyne Head	4	0.51	12	39.146	19.8	34.3	5.3
2008*	Slyne Head	0	0.41	0	39.146	16	26.7	5.2
2009	Slyne Head	6	0.31	7	39.146	12.2	19.2	5.1
2010	Slyne Head	7	0.73	4	39.146	28.7	32.3	25.1
2011	Slyne Head	7	0.51	5	39.146	20	25.1	14.8
2012	Slyne Head	3	0.52	2	39.146	20.5	23.3	17.7
2013	Slyne Head	4	0.54	10	39.146	21.1	33.8	8.3
2014	Slyne Head	4	0.28	6	39.146	11	18.8	3.2
2015	Slyne Head	5	0.5	4	39.146	19.6	24	15.2
2016	Slyne Head	4	0.3	3	39.146	10.8	16.0	5.5
2017	Slyne Head	4	0.24	4	39.146	10.7	15.3	6.7
2018	Slyne Head	5	0.84	12	39.146	33.0	46.5	19.6

* mean density estimated

Table 5: FU17: Results summary table for analysis of UWTV survey for the combined grounds.

Year	Abundance (Millions)	Upper bound	Lower bound
2002	1070	1154	985
2003	1246	1434	1059
2004	1410	1517	1302
2005	1092	1154	1030
2006	627	703	551
2007	920	982	858
2008	541	588	494
2009	696	739	653
2010	879	926	831
2011	672	720	624
2012	468	520	417
2013	441	506	376
2014	383	440	327
2015	556	627	484
2016	379	420	339
2017	404	445	362
2018	554	637	471

Table 6: FU17 Aran grounds: Summary of fish catches by tow in weight (kg) from 2018 fishing operations.

Species	Weight (kg)							
	Tow1	**Tow2**	**Tow3**	**Tow4**	**Tow5**	**Tow6**	**Tow7**	**Tow8**
AMMODYTES SPP	0	0.006	0	0.001	0	0	0	0.001
ARGENTINA SPHYRAENA	0.008	0	0.02	0.012	0	0.026	0.028	0.024
ARNOGLOSSUS LATERNA	0.024	0.008	0.012	0	0	0	0	0.012
BUGLOSSIDIUM LUTEUM	0.004	0	0	0.022	0	0	0	0
CALLIONYMUS LYRA	0.434	0.42	0.22	0.156	0.116	0.112	0.176	0.148
CALLIONYMUS MACULATUS	0.222	0.334	0.026	0.064	0.046	0.112	0.11	0.208
CARPOS APER	0.135	0.072	0.02	0.045	0.03	0.014	0.01	0.016
CONGER CONGER	0.086	0.19	0.066	0.026	0	0	0	0
ECHIODON DRUMMONDI	0	0	0	0.025	0	0	0	0.024
EUTRIGLA (CHELIDONICTHYS) GURNARDUS	0.43	0.184	0.08	0	0.15	0.052	0.046	0.064
GAIDROPSARUS VULGARIS	0.01	0	0.016	0.04	0.01	0.048	0.048	0.008
GADICULUS ARGENTEUS	0.006	0	0	0	0.022	0.006	0	0
GLYPTOCEPHALUS CYNOGLOSSUS	0.835	0.646	0.514	0.735	1.588	1.278	0.944	0.8
GOBIES	0.001	0	0	0	0	0	0	0
HIPPOGLOSSOIDES PLATESSOIDES	0.43	0.406	0.538	0.52	0.234	0.21	0.636	0.744
LEPIDORHOMBUS WHIFFIAGONIS	7.966	3.636	2.695	3.062	3.356	3.732	3.6	3.405
LIMINDA LIMANDA	0	0	0.1	0	0	0	0	0
LOPHIUS BUDEGASSA	0.34	0.918	0.41	0.1	0.422	1.36	0.846	0.732
LOPHIUS PISCATORIUS	1.296	0	0	0	0.202	0.026	0.832	0.13
MELANOGRAMMUS AEGLEFINUS	0.104	1.418	0.432	0.16	0.03	0.096	0.416	0.556
MERLANGIUS MERLANGUS	0.166	0.32	0.124	0.464	0.01	0.01	0.454	0.452
MERLUCCIUS MERLUCCIUS	0.232	0.16	0.132	0.31	0.404	0.104	0	0.458
MICROCHIRUS VARIEGATUS	0.336	0.036	0.018	0	0.026	0.042	0.04	0.032
MICROSTOMUS KITT	0.094	0.156	0.154	0	0.168	0	0.23	0.188
MICROMESISTIUS POUTASSOU	0	0	0.186	0.08	0	0.01	0.36	0.006
PHYCIS BLENNOIDES	0.008	0.044	0.03	0.03	0	0.036	0.036	0.046
SCYLIORHINUS CANICULA	0	0	0.884	0.825	0	0	0	1.202
SOLEA SOLEA	0	0	0	0	0.91	0	0	0
SPRATTUS SPRATTUS	0	0.07	0.352	0.044	0.006	0.012	0.088	0.026
TRISOPTERUS ESMARKI	0	0.13	0.27	0.555	0.034	0.184	0.292	0.306
Total Weight (kg)	13.167	9.154	7.299	7.276	7.764	7.470	9.192	9.588

Table 7: Inputs to catch scenarios table.

Year	Landings in number	Total discards in number *	Removals in number	UWTV abundance estimates	95% conf. intervals	Harvest rate	Mean weight in landings	Mean weight in discards	Discard rate	Dead discard rate
	millions	millions	millions	millions	millions	%	grammes	grammes	%	%
2002	55	18	68	1070	84	6.3	21.2	10.8	25	20
2003	44	18	58	1246	188	4.6	21.2	10.0	29	24
2004	29	11	38	1410	107	2.7	18.1	9.9	28	23
2005	42	20	57	1092	62	5.2	18.4	9.2	32	26
2006	NA	NA	50	627	76	7.9	NA	NA	NA	NA
2007	NA	NA	57	920	62	6.2	NA	NA	NA	NA
2008	48	22	65	541	47	12.0	21.9	11.2	31	26
2009	25	9	32	696	43	4.6	25.1	13.6	28	22
2010	37	15	49	879	47	5.6	25.2	14.7	29	23
2011	32	9	38	672	48	5.7	20.6	10.8	21	17
2012	60	8	66	468	52	14.4	20.9	10.4	11	9
2013	60	12	69	441	65	15.7	21.6	10.7	17	13
2014	34	5	38	383	57	9.8	22.6	9.6	13	10
2015	18	2	19	556	71	3.4	20.9	9.1	8	6
2016	30	6	35	379	41	9.2	21.2	10.9	17	14
2017	13.9	3.6	16.0	404	41	4.0	22.2	10.5	21	17
2018				554	83					

Table 8: FU17 Aran grounds: The basis for the catch scenarios.

Variable	Value	Notes
Stock abundance (2019)	554 million	UWTV survey 2018 (number of individuals).
Mean weight in wanted catch	22.2 g	Average 2008–2017.
Mean weight in unwanted catch	11.1 g	Average 2008–2017.
Unwanted catch	15.7%	Average 2015–2017 (proportion by number).
Discards survival	25%	Proportion by number.
Dead unwanted catch	12.3%	Average 2015–2017 (proportion by number).

Table 9: FU17 Aran grounds: Annual catch advice and scenarios; Discarding assumed to continue at recent average.

Basis	Total catch	Dead removals	Wanted catch*	Dead unwanted catch	Surviving unwanted catch	Harvest rate*	% advice change **
	WC+DUC+SUC	WC+DUC	WC	DUC	SUC	for WC+DUC	
ICES advice basis							
MSY approach	1002	980	916	65	22	8.5	81.8
Other options							
$F_{MSY\ lower}$	872	853	797	56	19	7.4	58.3
$F_{MSY\ upper}$***	1002	980	916	65	22	8.5	81.8
$F_{2015\text{-}2017}$	652	638	596	42	14	5.5	18.3
F_{2017}	466	456	426	30	10	4.0	-15.4

* By number.

** Advice value for 2019 relative to advice value for 2018.

*** $F_{MSY\ upper} = F_{MSY}$ for this stock